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Taiwan: National Science Council R&D Plans

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Taiwan: National Science Council R&D Plans

Outline of Plan

946B0085A Taipei K'OHSUEH FACHAN YUEK'AN [NATIONAL SCIENCE COUNCIL MONTHLY] in Chinese Vol 22 No 2, Feb 94 pp 103-104

[Article by Chang Li [1728 4539], Engineering Technology Development Department, National Science Council of Executive Yuan: "Introduction to R&D Plan of Engineering Department of National Science Council"]

[Text] After 10 years of dedicated effort, the atmosphere for engineering research is flourishing. Coupled with the greatly-improved research environment, the foundation for future development is established, as reflected in our ranking in the Engineering Publication Index. In 1992, the ranking moved up to 11th place, comparable to that of advanced European nations. However, further effort is needed to improve the publication quality even when our publication quantity exceeds the norm. Recently, a large number of engineering departments have been established in higher learning institutions. The research population has increased, and consequently, research funding requests have multiplied. In 1993 over 3,000 proposals applied for funding. In the next few years, research personnel will continue to grow, yet the budget cannot be raised proportionally. A "less gruel for more monks" situation will develop and worsen over time. Simultaneously, in the current changing global economy, domestic industry is facing a transition period of technological upgrade, demanding a great deal of research, development and technological assistance. In view of resource utilization and environmental changes, engineering technology research must adjust and adapt, plan, take initiatives, and unite all efforts to achieve research breakthrough and to secure a significant position in the academic world. To this end, the academic circles can lend support in numerous ways.

At present, the Engineering Department of the National Science Council offers the following fields of study: microelectronics and photoelectricity, telecommunication and signal processing, information engineering, control and electric power, medical engineering, machinery and solid mechanics, manufacturing, heat flow, energy resources, materials-metals and ceramics, polymers, ocean engineering, aeronautical engineering, space science, industrial engineering, chemical engineering, food engineering, civil engineering, and environmental engineering. Some fields have been established for a long time and some others, only one or two years. The research plans by various disciplines in the past are now too old, or lacking prominent focal points, or without the element of development policy or resource; therefore, renewed planning is necessary.

The coordination of engineering planning and available resources began in 1993. Through communication, coordination, and the consolidation of various opinions, it is expected to establish a long-range development base for the planning of academic research direction and resource utilization. The goal is to promote an academic research standard, and to move on to contribute to the national and social economy, and people's livelihood.

In principle, the starting point of the plan is to encourage long-range research. It is expected that academic research standards will be elevated through group efforts and teamwork, step by step according to schedule.

The selection of the plan's key items will be based on the following:

(1) the world's most current developments in prospective or innovative technologies,

(2) items in the Nation's long-range science program,

(3) technologies with industrial developmental potential, and

(4) technologies in coordination with R&D works at national laboratories or other organizations.

An order of priorities is established as one of the factors for program funding consideration.

As to effective resource utilization, present resources such as manpower, equipment, and instrumentation will be investigated, and future resource enhancement will be estimated. Next, research teams will be formed through program consolidation to cooperatively utilize resources with optimum efficiency. In the early stage, scholars and experts from the same research areas will organize into groups, and mutually related topics will be studied. After the completion of initial groundwork, projects are forwarded to key laboratories for cooperative research by division of labor. Depending on the achievements, distinguished research centers of international standards could be established and more resources will be invested in cutting-edge research.

To realize the plan, in addition to the aforementioned, items such as plan execution, as well as achievement evaluation and promotion are considered, and other supportive measures are also recommended.

The plan stipulates the following procedures: first the participants from all disciplines organize a planning group to coordinate and consolidate ideas from scholars and experts, including academic, industrial, and research institutes. By conducting informal discussions, and formal conferences from the base level to the top level on various occasions, the focus and direction for the development of each discipline will be drawn.

The current plan stresses the direction and guideline for engineering technology research in the next three to four years. This does not imply that individually initiated research will be excluded. Support for all proposed programs will eventually be determined by evaluation results, regardless of whether or not the programs are in the plan's prescribed disciplines.

When the plans of each and every discipline are completed by the end of 1993, they will be printed and widely publicized. The enforcement progress will be reviewed annually, and the plans will be modified and adjusted as necessary.

Plan for Automation Engineering

946B0085B Taipei K'OHSUEH FACHAN YUEK'AN [NATIONAL SCIENCE COUNCIL MONTHLY] in Chinese Vol 22 No 2, Feb 94 pp 105-112

[Article by Wang Kuohsiung [3769 0948 7160], Department of Mechanical Engineering, Central University: "Plan for Automation Field"]

[Text]

I. Introduction

Industrial automation is an achievement of the consolidation of different sciences and technologies. On Taiwan, the promotion of automation was planned in early 1981 by the Technology Consulting Group of the Executive Yuan. The National Science Council also aggressively joined the effort. The automation policy then was aimed at manufacturing industry. By 1989, the policy was expanded to include manufacturing, building, agriculture, and fishery, stock farming, and commerce. At present, the Engineering Department still focuses on manufacturing automation; while automation research on building industry is mainly conducted in civil engineering institutions; and that on agriculture, fishery, animal husbandry, and commerce, in related academic organizations.

II. Current Domestic Research

In the research and development (R&D) of manufacturing automation, other than the aggressive participation of automation disciplines, industrial engineering, machinery solid mechanics, and electrical engineering control are also promoting a number of research programs (Figure 1). Based on previous investigation of manpower and research projects, the personnel distribution ratio of public to private institutions is 3:1.

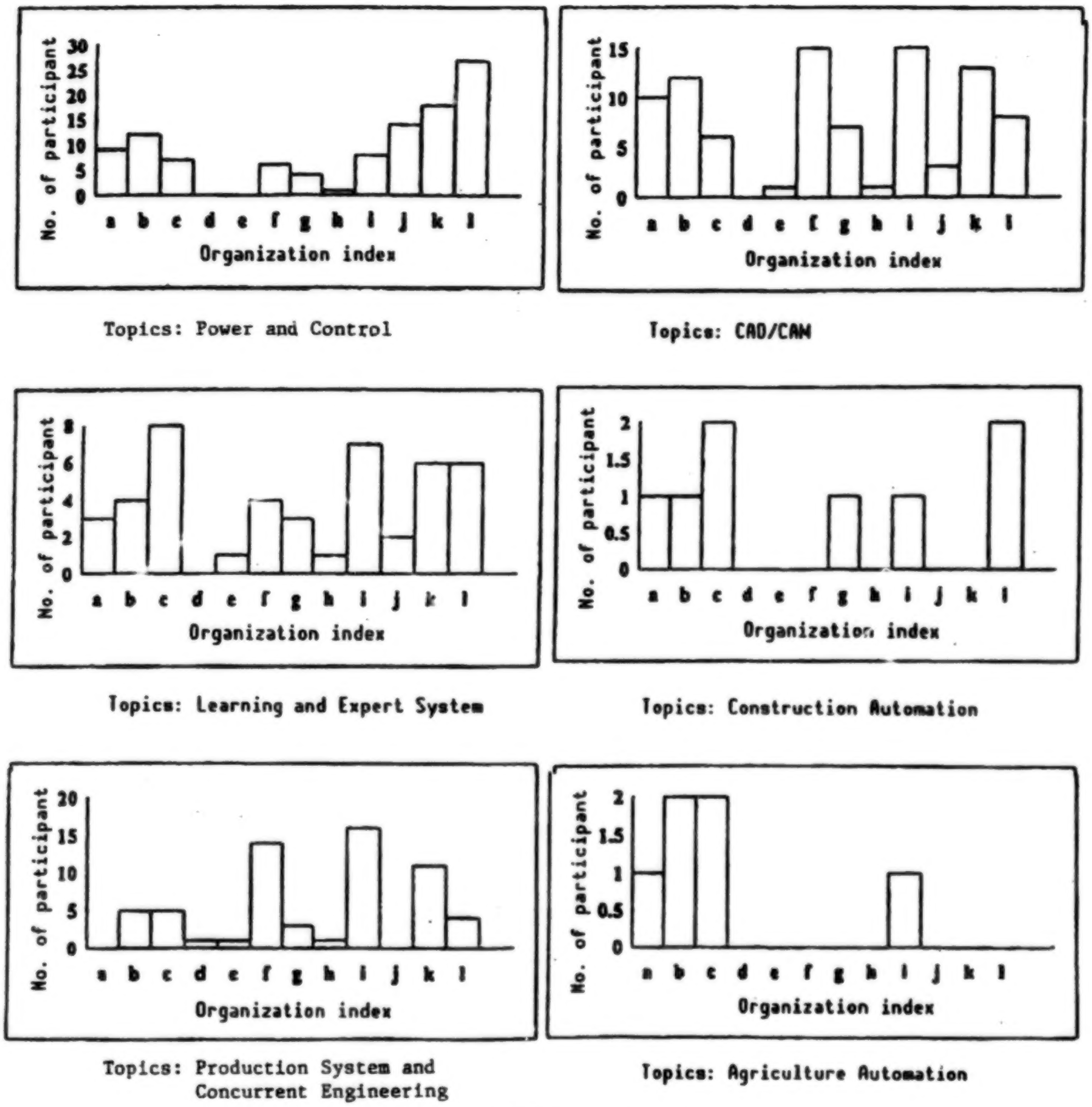

Figure 1. Manpower Survey

The research topics are as follows:

(1) Power and control: sponsored by Professor Li Anch'ien (Chiaot'ung University);

(2) Learning and expert system: sponsored by Professor Lin Jungch'ing (Taiwan Institute of Technology (TIT));

(3) Production system and concurrent systems: sponsored by Professor Liao Yunhsuan (Taiwan University);

(4) CAD/CAM: sponsored by Professor Hsiao Tehying (Tsinghua University);

(5) Construction automation: sponsored by Cheng Wenlung (TIT);

(6) Agriculture automation: sponsored by Professor Tung Pichih (Central University).

The research items are as follows:

(1) component design,

(2) design method,

(3) industrial application reliability,

(4) material inspection and processing,

(5) composite material application,

(6) cutting finishing,

(7) forming-processing system,

(8) welding system,

(9) manufacturing system,

(10) vehicle engineering (including AGV),

(11) machine tool (including production machinery),

(12) robots.

III. Program Focal Points

The procedures to carry out most of the programs are first to investigate and gather information, and then to organize discussions among related faculties, government units, and industrial personnel to prepare key research topics that meet domestic requirements.

(A) Power and Control

1. Robots and automatic machinery

(1) Intelligent robots.

(2) Vision feedback control system.

(3) Combined control of force and location.

(4) Automated assembling technique.

(5) Application of servo system in medical engineering.

(6) Application of servo system in production line automation.

2. Hybrid Man-Machine System

(1) Seeing-eye vehicle for the blind, guidance and control of unmanned transport vehicle.

(2) Establishment and application of dynamic simulating system.

(3) Intelligent crane.

3. Machine Tools

(1) Error measurement and compensation.

(2) High-speed magnetic-suspension shaft.

(3) R&D of intelligent control system.

(4) Flexible servo control system.

(5) Control of curved surface finishing machine tool.

4. Application of PC-Based Industrial Control

(1) Research of CNC interpolation technique.

(2) Control of turning manufacture.

(4) CAD/CAM: sponsored by Professor Hsiao Tehying (Tsinghua University).

(3) Automatic adjustment and control of the ejection forming condition.

5. Automotive Engineering

(1) R&D of engine microcomputer control system.

(2) Intelligent steering and gear shifting system.

(3) Intelligent control of automated suspension chassis.

(4) Vehicle direction guidance and positioning system.

(B) Learning and Expert System

Aimed at four industries (Research topics are in Table I)

(1) Parts and assemblies in automotive industry.

(2) Machine tool industry.

(3) Mold industry.

(4) Household electric appliance industry.

(C) Production System and Concurrent Industries

1. Flexible Manufacturing System

(1) Production system planning.

(2) Dynamic scheduling and control.

(3) System maintenance.

(4) Tool managing system.

(5) MIS.

2. Engineering for Concurrent Industries

(1) Product design.

(2) Manufacturing process design.

(3) Assembling design.

(4) Quality assurance design.

(5) Efficient utilization of resources.

The research topics listed under the above focal points are found in Table 2 and Table 3.

(D) CAD/CAM

1. CAD/CAM Integration Research

The research is aimed at topics related to CAD/CAM integration, which includes integration of CAD/CAM for mold design and fabrication, and research on factors that affect CAD/CAM integration, such as application of artificial intelligence, programing of tool travelling, CAD/CAE/CAM integration, flexible assembling system, visual system path program, cutting tool management and abnormality inspection and test system, and data interface research.

(3) Industrial application reliability.

(4) curved surface characteristic processing.

2. Design Automation

Research of design automation involves the establishment of software systems for the following: allowance analysis, CAD parameter design, CAD with special characteristics, mechanism composition, simulation of component assembling, rapid prototype fabrication, component automated selection system, product modeling, jig and fixture design, and optimizing design.

3. Establishment of Automatic 3D Computer Images for Measurement

This topic includes 3D measurement automation, and measurement inspection automation.

4. R&D of Special-Purpose CAD/CAM Systems

The R&D of special-purpose software are for these industries: shoe- manufacturing, punching dies, shipbuilding, aerospace, and mold-making. At the same time various databases and management systems can be established.

(E) Construction Automation

The construction management science and technology in the early stage are introduced from business management, industrial management, and special case management. Basic research on this body of knowledge covers the following:

1. Scope management.
2. Time management.
3. Cost management.
4. Risk Management.
5. Human resources management.
6. Contract/procurement management.
7. Communication and information management.

In order to concretely specify the groupings of research topics, the current construction automation classification is used as reference. The research groups are: automated plan design, construction technique automation, building management automation, building machinery automation, and building materials automation. Table 4 shows the classification of the research topics.

(F) Agriculture Automation

1. Agriculture Automation

(1) Pesticide and fertilizer application automation

a. Pipeline system planning

b. Pesticide system machinery and dosage control

c. Fertilizer application system and fertilizer diluting control system

d. Development and application of unmanned automated spraying machine

(2) Agricultural production automation

a. Automated seedling system

b. Automated greenhouse production system, including

(a) Hydroponics coordination technique

(b) Greenhouse micro-climate control

(c) Plant growth measurement

(d) Computerized environment control

c. Automated harvesting and processing, including cleaning, sorting, and packing

d. Storage and transportation automation

e. Refrigeration storage automation

(3) Automated agricultural waste management system

a. Automated collecting system

b. Automated treatment system

c. Automated composting system

2. Fishery Automation

(1) Fishing automation

a. Operation control system

b. Catch classification

c. Tackling and netting automation

d. Fishing product loading and unloading integration system

(2) Pisciculture automation

a. Automated fish pond cleaning system

b. Water quality and temperature automated monitor and warning system

c. Fishery automated harvesting and handling equipment

d. Automated feeding system

(3) Aquatic product processing automation

a. Large-scale fishery harvest classification, quantified packing

b. Aquatic product processing flow system

c. Fishery commodity loading and unloading, and auction facility automated system

3. Stock Farming Automation

(1) Feeding automation

a. Automated fodder mixing system

b. Automated fodder supply and feeding system

(2) Automated excrement treatment

a. Stock and poultry housing excrement cleaning and stock housing design

b. Stock and poultry solid waste drying and manure processing

c. Automated control system for stock farm waste-water treatment

(3) Egg and milk collection automation

a. Collecting, sorting, washing, selecting, and packing of egg and milk

b. Milking room management

(4) Stock farm management automated control system

a. Stock and poultry house ventilation, showering, and cooling system

b. Temperature control system of piglet delivery house

c. Stock and poultry quality inspection system

VI. Conclusions

The realization of automation is based on multidisciplinary technology, coordinated with most profitable measures. In conducting research, the system of the object of study is the central point, to which technologies of related interest are linked; in other words, the research is characterized as integrated research. It is expected that people in the various related disciplines could cooperate to attain the goal.

Table 1. Key Topics of Learning and Expert System Plan

Research topics in next five years	Automotive components	Die and mold industries	Machine tools	Household appliances
1. Computer-integrated manufacturing system	x		x	x
2. Development of fuzzy decision-making system	x	x	x	
3. Development of work-site information control system in manufacturing system	x	x	x	
4. Study of applying artificial intelligence on structural design optimization	x	x	x	
5. Study of intelligent jig design system based on deduction from case studies	x	x		
6. Study of applying artificial intelligence machine learning on machine design	x	x	x	
7. Study of intelligent industrial machinery design system	x	x	x	
8. Experimental study of A-type mechanical arm fuzzy learning controller	x		x	
9. Development of controlled feeding system for lathe			x	
10. Vibration monitoring, diagnosing, and control for mechanical system			x	
11. Intelligent machine tool control system			x	
12. Development of parallel microprocessor for intelligent ejection-molding machine controller			x	
13. Application of artificial intelligence and engineering data model on machine design	x	x	x	x
14. Intelligent machine component design system	x	x	x	
15. Integration of bill of materials (BOM) from production control and CAD/CAM	x		x	x
16. Computer-assisted workpiece clamping plan for five-shaft finishing			x	
17. Intelligent part assembling scheduling	x		x	x
18. Integrated research on intelligent production scheduling plan/rapid prototype system/electrical power-aided measurement	x	x	x	
19. Study of flexible servo control system			x	
20. Fuzzy-decision making system	x		x	x
21. Development of fuzzy neuro control system	x		x	x
22. Application of heredity calculation method on the optimum design of large-scale engineering project	x	x	x	
23. Study of hybrid universal optimization method		x	x	

Table 1. Key Topics of Learning and Expert System Plan (Continued)

Research topics in next five years	Automotive components	Die and mold industries	Machine tools	Household appliances
24. Study of the optimized design method for combined expert systems	x	x	x	x
25. Study of multi-tier design optimization			x	
26. Study of optimized environment and method on intelligent design	x	x	x	
27. Fuzzy optimized design of experimental statistical data	x	x		
28. Optimization of step-type design	x			
29. Optimized fuzzy step-type design	x			
30. Optimized fuzzy design for multi-purpose structure		x		

Table 2. Research Subjects in Production Systems

(1) Design and modeling of manufacturing processes*

(2) System design, modeling and simulation

Facilities layout

Material flow and handling

(3) Interface and integration of automation system components*

Integration of CAD/CAPP/CAM*

AGVS (Automated Guided Vehicle System)

AS/RS (Automated Storage and Retrieval System)

Industrial robots

CNC machines

CMM

FMS/FMC

(4) CIM system*

Networking

Database and knowledge base*

CAD/CAPP/CAM*

MIS

Cell/factory/shop floor control*

(5) Manufacturing planning and control

Operation planning

Production planning

Master production scheduling

Dynamic scheduling

Job assignment

HRP/MRP II

Shop floor monitoring and control

Inventory control

Logistics/distribution

(6) System integration*

Engineering database and manufacturing database*

MRP/MRP II and CAPP

Scheduling and shop floor control

(7) System operation-related

Troubleshooting

Maintenance

Reliability

Monitoring

(8) Intelligent manufacturing systems*

AI tools and applications*

(9) Management issues

Manufacturing strategy

Just-in-time/theory of constraint

Technology planning, management and assessment

Project management, CPM, PERT

Group technology

Engineering economics

* Denotes key subjects at present stage.

Table 3. Research Subjects in Concurrent Engineering

(1) Methodology issues:

Modeling of design and manufacturing processes*

Object-oriented planning and design*

Constraint-based design

Distributed framework

(2) Technique issues:

Design for manufacturability*

Design for assembly, reliability, etc.*

Feature-based design

Expert process planning

Automated NC programming and verification

(3) Tool issues

Object-oriented programming*

AI/expert system*

Machine learning*

Fuzzy system

Neural network computing

Computer visualization and animation

Networking

Parallel processing

(4) Product modeling issues:

PDES/STET*

Assembly representation and modeling*

Dimensioning and tolerancing*

Solid modeling and surface modeling

Representation scheme for design

Rapid prototyping

(5) System interface and integration*

(6) Others and related issues

Reverse engineering*

Quality engineering*

Value engineering*

Organizational transformation

Manufacturing system planning and design

* Denotes key subjects at present stage.

Table 4. Key Projects of Building and Construction Automation Plan

Research subject	Planning design (1)	Construction technique (2)	Building management (3)	Construction machinery (4)		Construction materials (5)
				Design	Mold	
(I) Planning Design Automation						
1. Whole-scale and calculation electronic data transmission	x	x	x	x	x	x
2. Data bank management system	x	x	x	x		x
3. CAD/CAM	x		x			
4. Computer simulation	x	x	x	x		
5. Automated profit analysis and productivity evaluation	x			x		
6. Automated feasibility analysis, potential capability evaluation	x			x		
(II) Construction Technique Automation						
1. Design and application coordination	x	x	x	x		x
2. Improvement of construction plan and productivity		x		x		
3. Foundation and underground engineering automation		x		x	x	
4. Steel structure construction automation		x		x	x	
5. RC structure construction automation		x		x	x	
6. Automation of installation and repair		x		x	x	
(III) Construction Management Automation						
1. Establishment of construction management computer system framework	x		x			
2. Development of integrated computer system	x		x			
3. Application of artificial intelligence	x		x			
4. Application of expert system	x		x			
5. Application of geographic information system	x		x			
6. Multi-media engineering technology or management information system	x		x			

Table 4. Key Projects of Building and Construction Automation Plan (Continued)

Research subject	Planning design (1)	Construction technique (2)	Building management (3)	Construction machinery (4)		Construction materials (5)
				Design	Mold	
(III) Construction Management Automation (continued)						
7. Supporting system of construction information decision- making	x		x			
8. Automated information collection and processing of construction site		x	x			
(IV) Construction Machinery Automation						
1. Machinery having matured technology, feasible for domestic development				x	x	
2. Long-range development of higher-level construction machinery				x	x	
3. Automated machinery design				x	x	
4. Automated machinery construction unit				x	x	
5. Development comparison of small hand tools and automated contruction machineries				x	x	
(V) Construction Material Automation						
1. Standardization of construction material						x
2. Automation of construction material production						x
3. Automation of construction material processing						x
4. Database management system						x

Plan for Medical Engineering, Control, and Electrical Engineering

946B0087A Taipei K'OHSUEH FACHAN YUEK'AN [NATIONAL SCIENCE COUNCIL MONTHLY] in Chinese Vol 22 No 2, Feb 94 pp 113-116

[Article by P'an Ch'ingts'ai [3382 2532 6299], Electrical Engineering Department of Tsinghua University]

[Text]

I. Introduction

The National Science Council presents this plan as a reference basis for the research and development (R&D) of the related fields of study in medical, control, and electrical engineering. The purpose is to efficiently coordinate the limited research personnel and funding to encourage long-range and group academic research to promote research standards and to speed up industrial technology upgrade.

The measures of the plan are to develop main R&D topics through conferences attended by representatives from industries, government, educational and research institutions, and based on national and international trends from industries. Then each main topic generates several subtopics. Experts are then assigned to make further study and name topics for potential research projects. These topics will then become references for the appropriate research institutes. The goal is that step by step research teams will be formed and the limited personnel and financial resources will be concentrated in the research of strategic key areas. This would contribute to domestic industries and raise academic research standard.

The following briefly introduces key R&D directions for medical, control, and electrical engineering.

II. Focal Points of Medical Engineering R&D Plan

Medical engineering is a research area which applies modern engineering theory and technology to life science and clinical medicine. Medical engineering, first known as bio-engineering and then bio-mechanics had its beginning in the 1960s. Recently, the scope of research becomes broader and more diversified. All branches of engineering technology: such as electrical engineering, electronics, information, materials, chemical engineering, mechanical engineering, etc., play an important part in medical engineering research.

In the past, medical engineering was a discipline of electrical engineering: however, to facilitate the cooperation of scholars in medicine, engineering, and science, in early March of 1990 (the 79th year of the Republic), the National Science Council convened the Conference on Future Development of Medical Engineering, and preliminarily planned the medical engineering research direction. In recent years, the number of researchers engaged in basic and applied research in medical engineering has increased rapidly, and considerable results have been produced. To achieve breakthrough in medical engineering research, the Council began the long-range planning in February 1993. After six conferences and two introductory sessions, conducted in both northern and southern Taiwan, participated by medical

engineers from research institutes, other experts as well as industrial representatives, the Council decided that research topics should include medical electronics and systems, bio-mechanics, and bio- medical materials. This plan explains the contents of all topics. It is hoped that resources can be centrally planned and utilized, in line with the needs of the nation as well as world outlook. This way, maximum efficiency of resources is obtained, talents are trained, research is encouraged to raise the nation's medical engineering standards and to improve people's health and welfare.

Medicine is mainly concerned with the maintenance and recovery of human health and function. The purpose of medicine has never changed, yet clinical theories and concepts, procedures and methods change with time and environment. It is predicted that the two main jobs of medicine, diagnosis and treatment, will change with the progress of engineering science and technology (S&T) and the demand of medical treatment. These changes lead the direction of medical engineering research both here and abroad.

Diagnostically, image technique and examination will be the mainstream tools. Examinations will move from using invasive methods to non- invasive methods, and the traditional way of examination will be replaced by real-time examination due to the introduction of computer and automation technology.

The traditional doctor-sponsored treatments will transform to coordinated, joint treatments by doctors, nurses, patients and engineering personnel. Increasing home care will replace hospital treatment to adapt to the aging of population and to control medical cost. Furthermore, the utilization of artificial organs will become a major trend.

The aforementioned changes in medicine will considerably affect the development of various branches of medical engineering. In the broad realm of medical engineering, areas for concentrated research can still be categorized as follows: medical electronics and systems, biomedical materials, and bio-mechanics (Table 1).

Table 1. Key Topics and Subtopics for Medical Engineering Research

Topics	Subtopics
Bio-medical materials	(1) Biologically adaptable materials
	(2) Soft tissue bio-medical materials
	(3) Sclerous tissue bio-medical materials
	(4) Biosensors
	(5) Bio-medical reactors
	(6) Control-release technique
Bio-mechanics	(1) Orthopedics mechanics
	(2) Rehabilitation engineering
	(3) Hemodynamics
Medical electronics and systems	(1) Physiological signal processing
	(2) Medical image processing
	(3) Medical data
	(4) Medical measurements and instruments
	(5) Bio-system simulation and control
	(6) Medical physics

III. Emphasis on Control Engineering R&D Plan

Traditional control theory has made speedy progress, but the application of control theory is somewhat lagging. Application control could be achieved through human experiences from learning, deduction, and even intuitive judgement, but these means of control are not systematic and can hardly be trusted. Because of this, intelligent-type control that combines artificial intelligent and traditional control theory have emerged.

In recent years, intelligent control has gained attention in control engineering. Primarily, it combines artificial intelligence and control theory for applications in industrial uses. Generally speaking, intelligent control consists of two categories: rule-base control, and neural network control. The mainstream in rule-base control is fuzzy control which is the current successfully industrialized application in the United States and Japan. The neural network control is still in the research stage, and its application in industries is limited.

Traditional control methods are essentially based on mathematical models. With the progress of time, more highly efficient but complicated control methods, such as adaptive control, robust control, etc., are developed. However, many problems in system model complexity and high uncertainty are still pending resolution. Especially, the redesign of traditional control method

requires complete overhaul from the beginning, which is undesirable economically. Intelligent control is developed because of these opportune conditions.

Generally, intelligent control can handle a wide range of systems. The non-linear system of complicated models can be successfully controlled through expert knowledge and experience or repetitive training. Additionally, intelligent control often produces control devices with higher profits and shorter redesign time. Therefore, intelligent control satisfies industrial requirements. Recently, due to the Japanese industrial R&D effort, many products labelled "Fuzzy" or "Neuro" have gained wide market support and response.

Accordingly, our very important task is how to encourage the triumvirate, production, research, and education, to work on the R&D of intelligent control to advance our technological standards and competitive capability.

Taiwan industry has an urgent demand for system integration technology. Because of the very low level of automation, most of the component assemblies are imported, which makes the cost of automation too high for the market to accept. On the other hand, technical supports provided by the dealers are limited. Lacking technology and experience, it is very difficult to promote system integration. Consequently, the design, technology, and market of system integration are monopolized by foreign businesses. The slow progress of basic industry makes it difficult to improve the marketing environment in a short period of time; however, system integration technology differs in the fact that it relies on interface technique, analytical planning and design capability, as well as computer software and hardware technology. Through hard work and promotion, these technologies have the opportunities for improvement in 10 or more years. Furthermore, the hardware costs of medium- and large- scale systems are relatively low. Once our system integration technology is achieved, the total system cost will be greatly reduced and the rate of successful operations will rise. This is why system integration technology is very much desired by industries, and long-range government policy support becomes even more crucial.

Precision motion control is an important link in precision machineries. Its application has expanded from aerospace, national defense, and instrument industries in the past to the present semiconductor, automation, and information industries. The production values of industries related to these fields are very great. These industries also progress from the part-assembly tier to the system tier, a key R&D item heavily invested by advanced countries.

Control theory and application are closely related. Too much consideration over control design could result in problems of feasibility, design complication problems, and problems from parameter restrictions which would be more difficult to resolve. Furthermore, the theories involved will multiply and become more difficult to understand. Therefore proper control theory matters greatly to control system design. This is especially true when the funding for control theory research comes practically from National Science Council only, while, by and large, control theories are numerous, and wide in scope. With the limited resources, our plan's main goal is how to select realistic topics of academic research value as well as application values.

Table 2 shows four planned key topics and their subtopics as described above.

Table 2. Key Topics and Subtopics for Control Engineering

Topics	Subtopics
Intelligent control	(1) Intelligent control technology
	(2) Application of industrial servos
	(3) Carrier control
	(4) Human-machine interface automation and humanization
System integration	(1) Theory and application of discrete dynamic system
	(2) Electromechanical integration technology and application
	(3) Industrial control system design
	(4) Analysis and design of computer-assisted control system
Precision motion control	(1) Precision control of driving motor
	(2) Computer control of machine tools
	(3) R&D and application of inductor and actuator
Basic control	(1) Function analysis theory
	(2) Nonlinear analysis
	(3) System discrimination and adaptive control
	(4) Basic control theory

IV. Focal Points of Electrical Engineering R&D Plan

Electrical engineering covers a vast territory and is indispensable for any electric installation. The applications of power systems range from a nationwide power network to a system for small appliances as well as systems for commercial airplanes or satellites high above, and submarines far below. The advancement of S&T has brought forth broader technical applications of electric systems. Therefore, the first understanding is that electric power S&T is a branch of high-tech and is a highly competitive field among nations, for instance: the minimization of size, weight, and bulk of information electrical system and the technical demand for high radiation-resistance and high reliability of electrical systems in satellites. These technologies may not be what money can buy.

Convenient electrical energy is the main reason for modern civilization and comfortable living. Its importance to national economic development is obvious. The first main topic of the plan includes several research items on the power system in order to provide safe, stable, reliable, superior, and inexpensive supply of electricity.

Next to the production of quality electrical power is the electricity utilization technology. Based on our special need, we divide the plan into two parts: power electronics, and electrical engineering mechanics. Briefly, power electronics technology utilizes solid semiconductor components to process the electric power resource, e.g. transforming the 60-cycle alternate current from the power company to direct current or current with different frequencies. The conversion technology for the limited energy resources affects transforming efficiency and production quality. Conversion technology is therefore another key technology, next only to information technology, for nations pursuing economic growth and international competition in the 21st century. It is a hot international R&D item in electrical engineering.

Taking the domestic utilization of electricity as an example: About 70% of electrical power in the nation is for industrial production in which the majority is used for driving electric machinery. In fact, production automation is no longer a new concept. Unfortunately, electrical machinery design and driving device technology on Taiwan are our weakness; consequently, we are extremely dependent on imports of related equipment. Actually, intelligent motion control, and power electronics are both very popular research areas internationally. This justifies its being the third important R&D topic. Table 3 shows the aforementioned four topics and their subtopics in the plan.

Table 3. Focal Topics and Subtopics for Electrical Engineering Plan

Topics	Subtopics
Power system	(1) Operation safety of power system
	(2) Quality of power system
	(3) Efficient utilization of energy resources
	(4) Electricity distribution system research
	(5) Rapid-transportation power system
	(6) High-speed train power system
Power electronics	(1) High efficiency and high intensity electric resources exchange system
	(2) Design, manufacturing, and modeling of electro-electronic components
	(3) Analysis and design computer-assisted electro-electronic system
	(4) Intelligent UPS technology
Electrical machineries	(1) Precision motor design and control
	(2) Motor driving technology
	—linear type
	—rotating type
	(3) Machinery (including electric power equipment) characteristic analysis, inspection, and protection.

V. Conclusion

The annual increase of our research population reflects the positive results from past funding. However, the situation that the funding has not proportionally increased, but decreased, causes concern. A review of recent research results shows that although our contribution to international academic publication has greatly increased, yet most of the publications are from individual efforts, and very few are collaborated papers. The research directions are very diverse, and lacking breakthrough from "concentrated, intensive problem-solving efforts." Additionally, pure theoretical research outnumbers research for practical applications. Facing the future of limited research personnel and funding, to pursue the goals of superb R&D achievements, the plan promotes cooperation among groups, selection of strategic focal points, selection of long-range R&D directions, consolidation of equipment utilization, and cooperation among institutions and nations.

For its smooth implementation, this plan contains more or less opinions from all sides, hence, its coverage in certain areas is somewhat too broad (referring to the current population for specialists). Due to this, the plan will be modified in the future as necessary. To carry out the plan, we appreciate the strong support of experts and scholars in the industrial, academic, and research circles.

Plan for Microwave, Communications and Signal Processing Engineering

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[Article by Pei Suchang [6296 5685 4545], Department of Electrical Engineering, Taiwan University]

[Text]

I. Introduction

(1) Background

In the mid-19th century, Maxwell established the complete theoretical framework that predicted the existence of electromagnetic waves, and by the end of the century, Marconi first successfully carried out radio communication. Since then electromagnetism has developed extremely fast in the 20th century. In less than 100 years, frequencies have been used from radio wave to microwave and then optical wave, a range covering tens of orders of magnitude. Other electromagnetic wave phenomena, including radiation, transmission, scattering, coupling, absorption, etc., have also been explored for application. Hence, electromagnetism is a key landmark in the development of civilization.

Electromagnetic applications cover a very wide range: military radar, tracking device, guided navigation, generator for heavy electric machineries, motor, transformer, strong magnet, magnetic levitation train, apparatus affecting daily life such as satellite, communication, broadcasting, television, fiber optics, mobile phone, microwave oven, electromagnetic range, medical equipment for diagnosis and examination, as well as applications in resource exploration, remote sensing, nondestructive inspection, and electromagnetic interference and compatibility used in electromagnetic pollution prevention. All the above are closely related to electromagnetic research.

Communication is to transmit any type of information or messages (e.g. data, words, graphics, sound and light, images, etc.) from one location to another through electrical technology. Traditional telephone, and television are typical examples. Signal processing is to further treat the signals (data, sound and light, image, etc.) with electrical techniques such as the traditional filtering and enlargement technique, etc., to facilitate utilization. Recently, because of rapid development of cutting-edge technologies (especially semiconductor and computer technologies) they practically completely changed the original look of microwave, communication and signal processing. The utilization of computers and large integrated circuits to treat signals has improved the potential for signal processing. The logical consolidation of communication transmission capability and computer processing capability will develop huge multi-function information system or network, which will speed up the early realization of the information age and the information society. With the assistance of computer and communication technology, the integrated service digital network (ISDN) is forthcoming any day now. Microwave, communication and signal processing are to become the three interlocked critical technologies. In view of the aforesaid, the Engineering Department of the National Science Council (NSC) drafted a comprehensive plan in order to raise the academic standard and technological level in these fields. The plan draws references from the current developments and programs of the Industrial Technology Research Institute, and the Telecommunication Bureau of the Department of Communication, present university research status, and development trends of science and technology (S&T) of other nations.

(2) Scope

Against the background of the aforementioned technological developments, this author preliminarily delineates the scope of "microwave, communication, and signal processing." In summary, electromagnetic research includes the following subjects:

1. Electromagnetic propagation and scattering.
2. Antennas and electromagnetic radiation.
3. Electromagnetic imaging and inverse scattering.
4. Microwave and optical wave techniques.
5. Electromagnetic numerical simulation techniques.
6. Electromagnetic interference and compatibility.

There are generally four tiers of development in "communication and signal processing":

1. Basic Technology

The indispensable basic technologies in "communication and signal processing" including

(1) Microelectronics: The major emphasis is on VLSI technology which is crucial in converting the most advanced conceptions to final products.

(2) Photonics: dealing with photoelectronic technology for communication and signal processing.

(3) Transmission theory: the study of basic information-transmitting theory.

(4) Digital signal processing: any technology using digits to process signals.

2. Transmission Systems

The aforementioned basic technologies can be applied to construct a transmission system to transmit information or message from one location to another. The major contents are:

(1) Transmission channel research: the research of properties and related problems of radio, cable, and optical fibers, etc.

(2) Transmission and reception technique: the technique of sending and receiving information through transmission channels.

(3) Transmission system design: the design of various special-purpose transmission systems.

(4) Transmission performance and quality: the analysis of transmission system performance and the quality of information received.

3. Network Technology

The interconnected transmission systems make it possible to transmit information from one location to other locations very conveniently. Thus a network is formed, and composed of the following:

(1) Switching technology: targeting specific locations to send messages through proper paths.

(2) Network protocol: protocol on information exchange within the network system.

(3) Network architecture: the architecture system for the building of network.

(4) Network design: the design of networks, for instance, the design of local area networks (LAN).

(5) Performance evaluation: the evaluation of network system efficiency.

4. Man-Machine Interface

Man-machine interface is the interface between users and network terminals (or any other machines), mainly for the purpose that man's voluntary functionalities (e.g. word, speech, voice, image, etc.) can be directly stored in the network system, and retrieved from the network system by the end user. It includes:

(1) Speech and audio processing: This enables the user to directly use speech or other types of sound (e.g. music) to enjoy the service from the network.

(2) Image and video processing: It enables the user to directly use image and visual means to enjoy the service from the network.

II. Current Research Status

In the last five years, the funding and number of research programs have increased drastically. In 1989 there were 102 projects; in 1990, 168; in 1991, 176; in 1992, 204; and in 1993, 296. Twenty-six organizations from academic and research circles took part in carrying out the plan. Among public universities, the following universities carry more projects: Taiwan University (U), Chiaot'ung U, Tsinghua U, Ch'engkung U, Central U, Chungshan U, Chungcheng U, and Taiwan Industrial Technology Research Institute ; among private universities, Chungyuan U, Tat'ung U, and Yuenchih U carry more projects. Tables 1, 2, and 3 show the funding, number of projects, and personnel in the last three years.

Table 1. Implementation Situation of Electrical Engineering Plan, 1991-1993, Engineering Department, NSC

Year and discipline		Research manpower (man-time)								Funding: in 1,000 yuan	Total projects
		Researchers in charge			Assistants				Total	NSC	
		Professor level	Associate professor level	Lecturer level	Teaching-assistant level	Graduate student	Lecturer level	Special assistant			
1991	Microwave	15	8	1	2	54	1	-	81	11,061	22
	Communications	15	22	-	-	80	-	1	118	13,618	31
	Signal processing	21	37	-	1	134	6	-	199	25,209	54
	Control	17	27	-	-	107	1	-	152	16,209	41
	Electric power	21	19	-	-	110	2	-	152	17,285	38
	Total	89	113	1	3	485	10	1	702	83,382	186

Table 1. Implementation Situation of Electrical Engineering Plan, 1991-1993, Engineering Department, NSC (Continued)

Year and discipline		Research manpower (man-time)								Funding: in 1,000 yuan	Total projects
		Researchers in charge			Assistants				Total	NSC	
		Professor level	Associate professor level	Lecturer level	Teaching-assistant level	Graduate student	Lecturer level	Special assistant			
1992	Microwave	16	16	-	-	69	-	-	101	10,829	27
	Communications	20	27	-	2	109	-	2	160	19,421	40
	Signal processing	41	30	-	-	175	-	3	249	31,049	66
	Control	21	32	-	-	131	1	-	185	20,291	50
	Electric power	32	28	-	4	154	2	-	220	23,819	57
	Total	130	133	-	6	638	3	5	915	105,409	240
1993	Microwave	19	16	-	2	61	-	-	98	10,895.4	35
	Communications	38	57	-	-	188	2	4	289	28,478.2	77
	Signal processing	38	39	-	1	169	1	1	249	23,593.8	68
	Control	28	29	-	3	139	3	-	202	18,997.8	55
	Electric power	29	43	-	1	172	6	2	253	26,799.5	61
	Total	152	184	-	7	729	12	7	1,091	108,764.7	296

Table 2. Research Manpower in Electrical Engineering, 1991-1993, Engineering Department, NSC

Year/Discipline	Microwave	Communication	Signal processing	Control	Electric power
	Research Manpower				
1991	81	118	199	152	152
1992	101	160	249	185	220
1993	98	289	249	202	253

Table 3. Fluctuation of Funding and Project in Electrical Engineering, 1991-1993, Engineering Department, NSC

Year/Discipline	Microwave		Communication		Signal processing		Control		Electrical Power	
	Budget (1,000 yuan) and Number of Projects									
1991	11,061	22	13,618	31	25,209	54	16,209	41	17,285	38
1992	10,829	27	19,421	40	31,049	66	20,291	50	23,819	57
1993	10,895.4	35	28,478.2	77	23,593.8	68	18,997.8	55	26,799.5	61

In 1993, it is estimated that the number of projects will exceed 300; and funding, 130 million yuan (Taiwan). In recent years, due to the influx of many young associate professors in the fields and expansions of many related institutes, the required research fund grows at the rate of 20% yearly.

Recently, the National Science Foundation in the United States published the priority directions of communication and network research. The integrated systems include: personal communication service and network, low orbit satellite network, high definition television, and optical communication system. The subtopics

include: coding consolidation and adjustment technique, data compression, message theory, information storage channel, system simulation and analysis, communication signal processing, radio systems and network, communication protocol theory, design and engineering, network interface architecture, dynamic network control, network linkage, optical communication network architecture, network safety and flexibility, exchange system, etc. The "2010 Technology Forecast Report" of the Japanese Economic Plan demands that importance be attached to the following technologies: multi-media communication technique, CDMA personal communication, optical household-system, very-small-apeture satellite terminal (VSAT) systems, high definition television, intelligent robot, fuzzy theory and near-neuro calculation, biological sensing, etc.

III. Plan for Key Research Fields

Research in the fields of "Microwave, Communication and Signal Processing" as promoted by the NSC can be categorized in three tiers for detailed planning:

1. Key Research Area: Key research topics are crucial items selected from those of considerable significance and developmental potential, and those having considerable domestic research basis. For each key research topic, a detailed and clearly defined plan is drafted to encourage the investment of manpower and resources so that concrete results can be achieved. The research results can be accumulated and become more effective, so that the "Key Research Team," currently promoted by NSC, can be provided with clearer research directions.
2. Directions for Prospective Study: Topics of significant developmental potential, emphasized by international academic or research circles but not adequately supported domestically, are selected according to domestic needs and environment. Plans will be prepared and basic reference materials on these selected topics will be provided to aggressively encourage the participation of research personnel.
3. General Research: This tier deals with research outside the other two tiers. It is also generally planned.

At present, the plan has drafted eight topics in the "key research field," six topics in "prospective study," and two areas in "general research," as listed in the following paragraphs. The details will be in the forthcoming publication "Invitation to Research Programs."

1. Key Research Fields
   - (1) Wireless communications and electromagnetic research development.
   - (2) Submillimeter wave technology and applications.
   - (3) Integrated circuit(IC) design for communications and signal processing systems.
   - (4) Fiber optical communications systems.
   - (5) Digital transmission.
   - (6) High-speed network technologies.
   - (7) Image and video processing.
   - (8) Speech and audio signal processing.
2. Prospective Study
   - (1) Communication security.
   - (2) Medical image processing.
   - (3) Digital color image processing.
   - (4) Multi-rate digital signal processing.
   - (5) Wavelets and their applications.
   - (6) Artificial intelligence (AI) applications in communications.
3. General Research
   - (1) Communication area.
   - (2) Signal processing area.

Based on these key areas of research and the nation's current research status, the author selects eight crucial research topics called "key research areas," which are considerably important, having developmental potential and existing research base. Detailed and specific plans are drafted to encourage the investment of personnel and resources. The author hopes that these topics will produce concrete results, and the results will be cumulated, and effectively utilized. The eight topics are:

1. Wireless communications and electromagnetic research development
2. Millimeter-wave technology and application.
3. IC design for communications and signal processing.
4. Fiber optical communications system.
5. Digital transmission.
6. High-speed network technology.
7. Image and video processing.
8. Speech and audio message processing.

To encourage long-range collective research, the Engineering Department of the NSC also pursues the "key research group" program; in fact, the "key research areas" have also considered the concept and the goals of the "key research group," in the hope of offering possible directions for the group. Hence, each "key research area" can be used as the content of a single research plan or a main topic for the "key research group."

IV. Key Points for Group Research Plan

(1) Research and development (R&D), and plan for HDTV Technology

HDTV is a television (TV) system with high quality image and audio system. It will be one of the major consumer electronic products. Its related products, such as high definition camera, video recorder, and disk camera, also have market potentials. Due to the HDTV system development, the related S&T, such as materials, high-speed microelectronic components and IC technology, visual message coding and high-density storage technology, and high-resolution photographic technology, will be vigorously developed. It is generally predicted that HDTV will be the motivating force for the development of high-speed electronics and state-of-the-art communication S&T in the 1990s. The influence of HDTV S&T will reach different society levels such as home, defense, medical treatment, education, entertainment, printing, etc. In February 1991, the Engineering Department of the NSC completed the drafting of the HDTV technology research plan, including the basic technology for HDTV development and design:

(1) vision system and chromatics,

(2) visual message signal processing,

(3) digital audio signal processing,

(4) high-speed IC,

(5) large-scale high-resolution monitor,

(6) visual message transmission and storage,

(7) multimedia technology,

(8) precision components.

Academic circles such as Taiwan U, Tsinghua U. Chiao-t'ung U, and Ch'engkung U have participated in NSC's HDTV group program for two years. With NSC funding and matching funds from the respective universities, they established HDTV laboratories in the northern, central, and southern regions of Taiwan, and conducted research on design of HDTV visual message, audio message, and large-scale IC. These universities form research groups and systematically integrate the HDTV technology; and at the same time work with industries such as the Electronic Communication Department of the Industrial Technology Research Institute, the Telecommunications Bureau of the Department of Transportation, and other electronic and television industries, to achieve research-industry-academic cooperation. This year, NSC is promoting resource investigation and installation integration, hoping to positively promote the sharing of resources, and group cooperation. The HDTV Program Panel Review and Evaluation held on 5 August 1993, and the Symposium on Group Resource Integration of HDTV Research held on 3 September 1993 surveyed the existing HDTV resources, equipment, and research spaces, and at the same time completed the drafting of a three- year plan for the "HDTV Laboratory".

The "HDTV Laboratory Planning Report" targets its investigation on Taiwan U, Tsinghua U, Chiaot'ung U, Ch'engkung U, Chungyuan U, the Telecommunication Bureau of the Department of Transportation, and the Multimedia Laboratory of the Electronic Communications Department of the Industrial Technology Research Institute. The report recommends the following guidelines for resource planning and integration:

1. General review of current research achievements.
2. Current laboratory equipment.
3. Equipment to be purchased in the future.
4. Space coordination in the institution.
5. Principle of utilization of laboratory space.
6. NSC or other research programs that are eligible for support.
7. Future plans.

Another purpose of the "HDTV Laboratory Program" is to promote mutual understanding among university research groups to share resources among themselves, and to make known to the outside world HDTV resources and laboratories so that research groups interested in HDTV research laboratories can enjoy the benefit and work cooperatively.

Every December, at the Conference for High-Definition Media Technology and Application, the NSC holds a Symposium on HDTV Research Achievements which is an open forum for the experts, system designers, and business persons to enjoy new R&D knowledge, product designs, and working experiences.

(2) R&D Plan for Wireless Communications S&T

In recent years the progress of wireless communications S&T has been very fast. Earlier application of wireless communications was in public telecommunications networks, satellite relays, mid- to long-range microwave relays, and military communication. Recently, its application has expanded to mobile phones and wireless phones. As a result of the progress of IC technology and telecommunications technology, mobile communications moves toward individual applications. The related techniques include network architecture, network management, telecommunications protocol, allotment and efficient utilization of channels, signal transmission technologies (e.g. information condensation, signal switching, coding technique, synchronized equalization techniques), as well as related IC design and manufacture (e.g. microwave IC, high-frequency circuit, signal processing and ultra- large IC for coding and decoding).

On 23 October, 6 November 1993, and 19 January 1994, NSC invited the nation's scholars and industrial personnel to three forums. A key cross- disciplinary plan for

the "wireless communications arena" between the communications and electronics fields was drafted. It is expected that by the end of February 1994 the key plan will be completed for the purpose of promoting the S&T development of radio communications. In addition, a "Wireless Communication Promotion Group" was organized to coordinate, assist, and upgrade the wireless communications industries in the country.

V. S&T Integration and Anticipated Goals

Due to the sharp increase of university teaching faculties, together with the increasing number of research projects, the funding for each project becomes restricted. Therefore, it is impossible to purchase large-scale instruments for every single project. Because many faculty members have similar specialties, group research will be continuously encouraged, and the small- and medium-sized instruments required by similar projects can be shared. Past data indicate that the growth of manpower in the microwave, communications, and signal processing fields is estimated to be 20 percent to 30 percent. Microwave, communications and signal processing are expected to achieve the following goals in the plan:

1. Promoting electrical engineering research, raising research standards, and strengthening the implementation of research achievements.
2. Reinforcing the internationalization, and sytemization of electrical engineering research; providing electrical engineering industries with concrete technologies and personnel.
3. Using resource integration and group research as a model to encourage academic research units to consolidate research goals and resources.
4. Promoting key R&D efforts in electrical engineering, e.g. the development of high definition visual communication industries, wireless S&T development, telecommunications network research and development, etc.

VI. Conclusions

This plan was drafted by mobilizing numerous university faculties and related research personnel. It took six months. The expectation is that through the long-range cooperative efforts of all research colleagues, the many research entities in all universities could have a more shared direction and more concentrated force. Experiences and achievements can be mutually exchanged to jointly raise our technical and research standards in the concerned fields.

Plan for Metals and Ceramic Materials Engineering

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[Article by Huang Minhsiung [3163 2404 7160], Department of Materials of Ch'engkung University]

[Text]

I. Introduction

In recent years, owing to the rapid progress of material science and technology (S&T), many new materials are created, and new functions of many old materials are successfully explored. The development has greatly affected engineering S&T. To promote an industrial S&T standard, the Government has strongly encouraged the research and development (R&D) of material science and engineering. In education circles, the existing material science departments keep on expanding, engaging many faculties with material specialty, and new material science departments have mushroomed, resulting in the continuous increase of research personnel in the academic material field. All this creates a new flourishing atmosphere. Up to now, there are over 120 faculty members whose research works in the metal and ceramic field have been funded by the National Science Council (NSC). Every year, about 150 research projects in material science and engineering are conducted. The projects include research on structural materials such as iron and steel, aluminum alloys, metal matrix composites, and structural ceramics; and functional materials such as electronic ceramics, magnetic materials, optoelectrical material, memory alloys, and biomedical materials; and also material fracture and inspection such as corrosion, abrasive erosion, fracture analysis, etc..

Material S&T itself plays a supportive role. As materials are needed for all other science and engineering fields such as aeronautics, communications, as well as mechanical, electronic, civil, architectural, and chemical engineering, etc., the scope of material research is intrinsically very diversified; consequently, it is difficult to concentrate the S&T effort only in one area. Under the condition of limited government budget for material science, about NT$80 million annually, if the research projects are not properly integrated, the limited manpower and funding cannot achieve any obvious results. Therefore, "research cluster" is suggested for areas having greater number of research personnel.

The research clusters, will be assigned aggressive functions. On the one hand, they will help material science studies, make plans of future research directions, and further establish research groups. On the other hand, through annual symposiums and achievement presentation meetings held by the research cluster, the groups can make mutually beneficial discussions. With group effort, the R&D of material S&T can be advanced to a higher level, the materials demands from the "Six-Year National Construction Plan" will have support, and our academic standard will be promoted.

Through intensive discussions among close to 100 professors for over two months, six preliminary research clusters in the material discipline are organized. Future short- and mid-range goals are separately drafted. After these plans are put into practice, annually they will be

discussed and revised in response to academic and industrial demands at home.

II. Analysis and Comparison of Related Research Abroad and at Home

(1) Trends of International Material R&D

Any material development and breakthrough of new material manufacturing technology will create some new industries. Therefore, developed nations give priority to new materials development and processing techniques. Japan has made materials development the primary item for "Building the Nation on S&T." In the United States the White House Office of Science and Technology Policy (OSTP) has selected 22 future key S&T items. The first five choices are all material S&T items: material synthesizing and processing, optoelectric materials, ceramic materials, composite materials, and high-performance metals and alloys. European nations are engaged in the "Leading Technology Research Cooperative Plan" which contains: fifth- generation computers, microelectronics, optoelectric technology, and new materials, all of which have materials S&T as the leading force. From the above, we can see the importance of materials S&T. The international development trends of material S&T are summarized as follows:

1. Space material: light weight, high-temperature resistant, and high strength.
2. Aeronautical material: environmental corrosion fracture resistance, and lengthened material life.
3. Structural material: high elasticity, and high-specific strength.
4. Electronic material: light, thin, short, and small.
5. Energy conversion material: energy-saving, new ceramics, and new pollution-resistant battery material.
6. Sensing material: high sensitivity, and intelligent.
7. Bio-medical material: molecular engineering, super-microstructure, artificial human organ substitutes, and transplant adaptability.

8.Revolutionary material: high-temperature superconductor, diamond film, and carbon-60.

(2) Domestic Material R&D Status

In 1992, NSC funded about 151 research programs conducted at university material science departments, which can be roughly classified into six major categories as follows: casting and steel making, light alloy and metal matrix composite materials, structural ceramics, electronic ceramics, material corrosion and its prevention, and hard film materials. Other programs include iron and steel materials and their processing, alloys, biomedical materials, magnetic materials, optoelectronics materials, etc.

In addition, the Engineering Material Department of the Industrial Technology Research Institute did extensive research on materials for mechanical transportation devices and superconductors. The Material Development Center of Academia Sinica had considerable accomplishments on superalloys, and high-temperature-resistant ceramics research. The Metal Research Center conducts R&D on metal surface treatment, casting, and welding. China Steel Company pays special attention to the steel and aluminum smelting and refining and their processing.

III. Introduction to Planning Process and Plan Contents

(1) Planning Process

To effectively plan the materials science research directions, conveners of the six research clusters were invited. The professors are: Huang Wenhsing for casting and steel refining, Kao Powei for light alloys and metallic matrix composite materials, Wei Wench'eng for structural ceramics, Ts'ai Wenta for material corrosion and corrosion prevention, and Shih Hanchang for hard film materials. The conveners then invited nucleus members of related studies to map out the preliminary major research directions for the respective field. Finally, forums of university faculties from the related fields were held to discuss and decide on research directions. After two months, a preliminary mutual understanding was reached.

(2) Plan Contents

After two months of numerous meetings pooling ideas from over 100 participants, the preliminary conclusions are as follows:

1. Casting and Steel Making

Key research directions are:

(1) High-quality nodular cast iron: production process, project design, mold making, microstructure, mechanical property, refining, and continuous casting.

(2) Aluminum alloy: production process, project design, mold making, microstructures, mechanical properties, and refining.

(3) Alloy steel: refining, continuous casting, microstructure, and mechanical property, etc.

Key research topics are:

(1) Development of Al-Si-Mg alloy vanishing mold process: including project design, mold making, melting, refining, casting function inspection, post-treatment and finishing.

(2) Research and exploration of austempering nodular cast iron gear casting: including melting, alloying design, heat treatment, project design, mechanical properties, post-treatment and finishing, and function and property inspection.

2. Light Alloy and Metal Matrix Composite Materials

The key research directions are aluminum alloys, titanium alloys, Ni-Al and Ti-Al intermetallic alloys, as well as the design, making, processing, and property evaluation of alloys for metal matrix composite materials.

The key research topics are:

(1) Exploration of new aluminum alloys: including alloy design, manufacturing process, fabricating, microstructure analysis, and property evaluation.

(2) Superplastic forming and joining technique of aluminum alloy: including superplastic forming process and mechanism, solid state joining, and diffusion joining.

(3) Improvement of traditional aluminum alloy's properties and manufacturing process: including forming and strength improvement, rolling and annealing improvement, and the structure control of recrystallization.

(4) Matrix composition design for aluminum composite material: including improvement of the boundary compatibility between the matrix and the reinforcing phase, matrix strength, and corrosion resistance.

(5) Aluminum composites: including manufacturing process, and forming process, as well as the reinforcement material such as particulates, fiber crystals, short fibers, and long fibers.

(6) Evaluation of aluminum matrix composite: including the mechanical, physical, frictional, and corrosion resistant properties.

(7) Aluminum matrix composites, their properties as affected by the making, processing, and microstructures: including reinforcing mechanism, process parameters, microstructures, and the relationships among them.

(8) Interface reaction of aluminum matrix and ceramic reinforcing materials: including the analysis of the interface microstructure, and the establishment of phase diagrams.

(9) Forming and joining technique of titanium alloy: including superplastic forming, isothermal forging, diffusion joining, and solid state joining.

(10) Exploration of Ni-Al and Ti-Al intermetallic alloys: including alloy design, mechanical property evaluation, plastic deformation mechanism, thermal mechanical treatment, microstructure analysis and phase transformation, melting and casting, powder metallurgy, and reactive sintering.

3. Structural Ceramics

This research cluster has nine major research directions:

(1) Study of the relationship between the microstructure characteristics and the abrasive erosion properties of structural ceramics: establishing abrasive erosion data of various ceramic materials, understanding their relationship with the microstructure of engineering ceramics (e.g. cutting tools).

(2) R&D of the near-net-shape process: improving the capability of making complicated-shape ceramics by the near-net-shape process (e.g. ejection forming) so that the technique can be soon transferred to industrial use.

(3) Study of design and manufacturing process of ceramics with special structural functions: for breaking through the function limits of present single-phase, and single-composition ceramics; improving ceramic structural properties with methods such as bi-layer, multi-layer, and second-phase dispersion (e.g. nanoscale composite material).

(4) Establishing manufacturing technique for perfect high-temperature anti-fretting components.

(5) Establishing the standard testing technique for anti-fretting and mid- and high-temperature structural ceramics: the standard testing technique can provide comparisons, and establish information and data.

(6) R&D of submicron (nanoscale) class composites: applied to designs that enhance and highlight the structural characteristics of ceramics.

(7) Improving the near-net-shape process from the aspects of environmental protection and cost: following international trends, and domestic industry requirements.

(8) Developing the surface strengthening technique of structural ceramics: strengthening and bettering the anti-fretting properties of ceramic surfaces, by incorporating areas of study related to surface filming and property modification techniques.

(9) Research on the high-temperature elastic-plastic properties of structural ceramics: basic research of future high-temperature plastic processing, and forming.

4. Electronic Ceramics

This research cluster outlines three key research directions:

(1) Sensing and actuating ceramics and their mechanism: including the development and the functional mechanism research of ceramics with the functions of sensing and reacting to signals of electricity, light, magnetism, heat, pressure, radiation, and gas.

(2) Research of making ceramic component into thin film, and the ceramic thin film component: including the research of making electronic ceramic block components from thin films (including thick films), and the process and property studies of electronic thin film technique for microelectronic components.

(3) Research and manufacturing of ceramic component for information and communication applications: including dielectric ceramic resonators, filters, and memory elements.

5. Material Corrosion and Corrosion Prevention

In the maritime climate of Taiwan, research on material corrosion and corrosion prevention is very important. The plan includes five major directions:

(1) Corrosion induced fracture: including stress corrosion, hydrogen brittleness, corrosion fatigue, liquid metal-induced fracture, and impact corrosion.

(2) High-temperature corrosion: including oxidation, sulfurization, chlorination, carbonization, mixed gas corrosion, heat corrosion, and corrosion-prevention technology.

(3) Ocean corrosion: including ocean material corrosion, development of ocean-corrosion-resistant material, RC corrosion prevention and treatment, ocean biological corrosion, and corrosion prevention for ocean structures and ships.

(4) Atmosphere corrosion: atmosphere corrosion mechanism, thermodynamics, environmental factors, material life evaluation, acceleration test method, and development of anti-corrosion technology.

(5) Corrosion inhibitor: including organic inhibitor, inorganic inhibitor, gas inhibitor, etc.

6. Hard Film Materials

The key research directions are as follows:

(1) Development of superhard film: including the R&D of traditional hard films such as nitrides and carbides of titanium, zirconium, hafnium, and chromium; the R&D of new superhard films such as diamond film, amorphous diamond carbon film, cubic boron nitride; and the theoretically-designed superhard materials such as C-N compound, etc.

(2) Establishment of the technical capability to evaluate hard film properties: including evaluation techniques such as crystal structure, microstructure, and composition distribution; the establishment of hard film mechanical properties such as hardness, compressive stress, modulus of elasticity, internal stress, fracture durability, adhesiveness to the base material, and lubricant properties; as well as establishment of industry-education cooperation in hard-film property evaluation.

IV. Anticipated Results and Forecast

The research of material science and engineering tends to become diversified, because material properties are different and scopes of applications vary. However, after this preliminary plan integration, it is anticipated that at least more than 10 research clusters with guided directions will be established, and these clusters will distinguish the material science departments of their respective schools. Moreover, many scholars, research institute staffs, and industrial personnel were invited to cooperatively draft this plan, hence, future research topics will be realized gradually in terms of domestic needs and characteristics.

V. Conclusions

In formulating the metals and ceramic materials plan, and in its implementation, the Engineering Department of NSC assumed leadership position. The drafting was jointly done by material science department faculties of all universities and other material science experts. Although the plan has been deliberated numerous times, yet it is still not perfect. After it is put into practice, it will be continuously and cooperatively re-examined and revised for improvement so that the national materials S&T level is advanced, and the national construction demand is met.

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